ABSORPTION REFRIGERATOR WITH ICE-MAKER

Field of the invention

The present invention relates to an absorption refrigerator including; a cabinet having outer walls and at least one door encasing a low temperature storage compartment and a higher temperature storage compartment, said compartments being separated by a partition wall, a device for ice fabrication, and an absorption refrigerating system including an evaporator tube in which a refrigeration medium flows from an upstream end to a downstream end of the evaporator tube, and which evaporator tube comprises a first tube section which is arranged to absorb heat from the low temperature compartment, a second tube section, which is arranged to absorb heat from the higher temperature compartment and a third tube section which is arranged to absorb heat from the ice fabrication device, wherein the first, second and third tube sections are connected in series and the first tube section is arranged upstream of the second tube section.

Background of the invention

Such absorption refrigerators are commonly used e.g. in recreation vehicles, mobile homes or at homes were AC power supply is not available at all times.

Normally, at the prior art refrigerators of this type, the lower temperature compartment is a freezer, which at modern absorption refrigerators normally is maintained at -18 °C. The freezer also accommodates the device for fabrication of ice, often referred to as the ice-maker. The ice maker may in it's simplest form be an ice-cube container but it may also comprise more sophisticated devices with means for automatic water supply and ice harvesting means including mechanical

members and electrical heating elements. The higher temperature compartment is normally maintained at around +5 °C and could be referred to as a refrigerator compartment.

The evaporator tube includes an upstream tube section, which is dedicated for cooling the ice-maker. Downstream of this ice-maker tube section and in direct connection to its downstream end, an intermediate tube section is arranged for cooling the freezer. Downstream of the freezer section, a downstream refrigerator section of the evaporator tube is arranged for cooling the higher temperature refrigerator compartment. At some applications both the freezer and the ice-maker are cooled together by one single evaporator tube section which is arranged upstream of the refrigerator tube section.

The evaporator may be provided with various types of heat conducting members for conducting heat from the items to be cooled, i.e. the freezer and refrigerator compartments and the ice maker, to the respective evaporator tube sections. As an example, the ice-maker section of the evaporator may be provided with a heat conducting plate, which is arranged to support the ice-cube fabrication container and which conducts heat from the container to the ice-maker section of the evaporator. The freezer and refrigerator sections may be provided with flanges or baffles, which conduct heat from the air in the freezer and refrigerator compartments to the evaporator freezer and refrigerator section respectively.

The evaporator tube sections and/or the respective heat conducting members may further be provided with means for defrosting. Such defrosting means may comprise heating means such as an electrically heated film which is activated at regular intervals or when the build up of frost has reached a

certain level. Upon activation of the heated film frost is melted.

The evaporator reaches its lowest evaporation temperature at the upstream end. Downstream of the upstream end, the evaporation temperature rises gradually when the cooling medium in the evaporator tub absorbs heat from the ice-maker, freezer compartment and refrigerator compartment.

A problem at this known type of absorption refrigerator is that it is difficult to achieve a high enough cooling power of the refrigeration system to maintain the freezer compartment at the low temperature which is desired. As mentioned above, it is often desired to keep the temperature in the freezer compartment as low as approximately –18 °C. The total cooling power of the absorption refrigerating apparatus is, among other factors, limited by the heat transfer capacity of the evaporator, which in turn depends on the total length of the evaporator tube. This length in turn, is limited by the dimensions of the refrigerator cabinet and by the fact that the evaporator tube needs to be designed with a downward inclination over its entire length, from the upstream to the downstream end.

At the upstream end of the evaporator tube, the evaporation temperature of the refrigeration medium is normally approximately –30 °C. During manufacturing of ice, i.e. during freezing of water in the ice-maker, the ice-maker section of the evaporator absorbs heat from the ice-maker. This heat absorption rises the evaporation temperature of the refrigeration medium so that it, at the entrance of the freezer section of the evaporator tube, is approximately -24 °C and at the exit approximately –20 °C. Thus, during manufacturing of ice, the average driving temperature

difference between the desired freezer temperature and the evaporation temperature of the refrigeration medium would then be only about 2 °C. Such a small driving temperature difference makes it impossible to bring down the freezer to the desired temperature, especially when additional heat enters into the freezer, e.g. due to opening of the freezer door, placement of non-frozen items in the freezer or due to inward heat transfer through the cabinet walls. Especially when utilizing some kinds of automatic ice-makers, this problem is further increased. During harvesting of the ice in such automatic ice-makers, the ice-container is heated by an electrical heating element. Hereby, the heat supplied to, and absorbed by the refrigeration medium in the ice-maker section of the evaporator tube is further increased. The cooling capacity available at the freezer evaporator section, downstream of the ice-maker evaporator section is thus further reduced during automatic harvesting of ice. In practice, it has shown that the temperature in the freezer compartment rises between 6-9 °C during operation of such automatic ice-makers. Also at the type of absorption refrigerators, where the ice manufacturing device and the freezer compartment are cooled by one and the same evaporator tube section, the same negative influence of the ice-maker on the cooling capacity in the freezer compartment applies.

A further problem associated with ice-makers and particularly with automatic ice-makers is the humidity which is transferred from the ice-maker to the air in the refrigerator during supply of water and during heating the ice prior to harvesting. The humidity which is transferred to the air during water supply and heating, does to a large extent contribute to the formation of frost on the cool surfaces, i.e. the evaporators or the heat conducting members arranged

in the compartments or spaces with which air coming in contact with the ice-maker communicates. Thus, humidity released from the water in the ice-maker prior to freezing of the water to ice and at harvesting heating is absorbed by the air and circulated to the cool surfaces, where it forms frost on these surfaces.

Brief summary of the invention

It is therefore an object of the present invention to provide an absorption refrigerator having a low temperature compartment, a higher temperature compartment and an ice manufacturing device, at which absorption refrigerator the total cooling power of the refrigeration apparatus is more favorably distributed between the two compartments and the ice-maker.

It is a further object to provide such an absorption refrigerator, which facilitates to maintain the temperature in the freezer compartment as low as desired, also when additional heat is entered into the freezer compartment.

Another object is to provide such an absorption refrigerator at which it is possible to use sophisticated ice-making devices including heating elements without adversely affecting the cooling capacity of the freezer compartment.

A still further object is to provide such an absorption refrigerator at which the negative effects caused by the humidity load generated by the ice-maker may be prevented or reduced by utilizing the defrosting means associated with the freezer evaporator or the refrigerator evaporator.

These and other objects are achieved with an absorption refrigerator according to the first paragraph of this description in which refrigerator the third tube section is

arranged to predominantly absorb heat from the ice fabrication device by heat conduction and is arranged downstream of said first tube section and upstream of said second tube section and in which the ice fabrication device is exposed to air circulating in the low temperature compartment, wherein means are provided for melting frost generated by humidity in said low temperature compartment or said higher temperature compartment respectively.

Through this arrangement of the different sections of the evaporator tube, the first evaporator tube section, which absorbs heat from the freezer compartment is arranged the most upstream of the three sections. Hereby it is assured that that section of the evaporator tube which exhibits the lowest evaporation temperature cools the item, which needs to be maintained at the lowest temperature, i.e. the freezer compartment. Thereby, it is also assured that the greatest possible driving temperature difference is used for maintaining the freezer compartment at the desired temperature.

Since the ice-manufacturing device needs to be kept only at about -10 °C for sufficiently quick freezing of water to ice, the increase of the evaporation temperature, which the refrigeration medium undergoes during its absorption of heat in the freezer tube section of the evaporator does not adversely affect the capability of the ice-maker section to maintain the ice-maker at a sufficiently low temperature.

The refrigerator compartment in turn, needs only to be kept at about +5 °C. Therefore, the increase of the evaporation temperature, which the refrigeration medium undergoes during its passage through the ice-maker section of the evaporator does not adversely affect the ability of the refrigeration

section to maintain the refrigeration compartment at the desired temperature.

Since the ice fabrication device is exposed to air circulating in the low or higher temperature compartment, it is further guaranteed that the humidity load caused by the ice-maker and absorbed by the air will be circulated to pass the freezer or refrigerator evaporator or its heat conducting means such that the frost resulting by this humidity may be defrosted by defrosting means associated with the freezer or refrigerator evaporator. By this means, no additional defrosting means needs to be provided for taking care of frost caused by the excessive humidity load added by the ice-maker.

Thus, by the arrangement of the different evaporator sections according to the invention, it is assured that the total cooling capacity generated by the refrigeration apparatus is distributed by the evaporator to the items to be cooled in the most effective manner at the same time as no additional defrosting means needs to be arranged for eliminating frost generated by the humidity load caused by the ice-maker.

Further objects and advantages of the invention are set out in the depending claims.

Detailed description of the invention

An exemplifying embodiment of the invention will now be described with reference to the accompanying drawings in which:

Fig. 1 is a top elevation view, with parts of the walls broken away, of a refrigerator cabinet according to the present invention.

Fig. 2 is a perspective view from behind, with parts broken away, of the refrigerator in fig. 1.

In the figures a side-by-side absorption refrigerator 1 is shown. The cabinet includes a rear wall 2, two side walls 3, 4, a top-wall 5 and a bottom-wall 6. These outer walls 2-6, together with two front doors 7, 8 enclose a low temperature storage compartment 9 and a higher temperature storage compartment 10. The outer walls 2-6 and the front doors 7, 8 all include an outer and an inner shell between which heat insulating material, such as polyurethane foam, is arranged. The two compartments 9, 10 are hermetically sealed from each other by a vertical partition wall 11, which extends perpendicular to and from the rear wall 2, between the rear wall 2 and the front of the cabinet 1, in such away that the doors 7 and 8, when closed, sealingly rest against the front of the partition wall 11. The freezer compartment 9 is thus defined by the (in fig. 1) left front door 7, the partition wall 11, the side wall 3, and respective portions 2a, 5a, and 6a of the rear wall, top wall and bottom wall. The higher temperature compartment 10 is analogously defined by the (in fig. 1) right front door 8, the partition wall 11, the side wall 4, and respective portions 2b, 5b, 6b of the rear wall, top wall and bottom wall. The partition wall is placed approximately 1/3 of the total width of the cabinet from one side-wall 3, so that the width-relationship between the freezer compartment 9 and the refrigerator compartment is approximately 1:2.

During operation, the temperature in the freezer compartment is normally kept at about -18 °C, whereas the higher temperature compartment normally is kept at about +5 °C. The higher temperature compartment 10 could also be referred to as a refrigerator compartment.

An absorption refrigerator system including a conventional boiler, condenser, and absorber (neither of which is shown) is arranged at the back of the cabinet, outside the rear wall 2. The refrigerator system also includes an evaporator, generally indicated by reference number 20. The evaporator 20 is formed of an evaporator tube, which includes a first evaporator tube section 21 for cooling the freezer compartment and a second evaporator tube section 22 for cooling the higher temperature compartment 10. The first section 21 is arranged inside the freezer compartment 9 and the second section 22 inside the higher temperature compartment 10.

The evaporator tube 20 also includes a third tube section 23 for cooling a device (not shown) for fabrication of ice, hereinafter referred to as an ice-maker. The ice-maker may in its simplest form be an ice-cube container, which is placed onto the third evaporator section. It may however also be a more sophisticated automatic device, including means for automatic water supply, mechanical means for harvesting and crushing the ice as well as electrical heating elements for partially melting the ice prior to harvesting. Regardless of which type of ice maker is used, it is arranged such that the predominant amount of heat, which is removed from the water during the fabrication of ice, is conducted to the third section of the evaporator.

The three evaporator sections 21, 22 and 23 are arranged in series such that the evaporator tube is formed by one single continuous tube, which includes the three sections, one after the other. The first section 21 for cooling the freezer is arranged the most upstream. The third section 23 for cooling the ice-maker is arranged directly downstream of the first section. The second section 22 for cooling the refrigerator is arranged downstream of the third section 23.

At the upper, upstream end 24 of the evaporator 20, a first conduit 25 supplies the coolant, such as liquid ammonium, from the condenser to the evaporator 20. At the same upstream end 24, a second conduit 26 supplies poor gas from the absorber.

The first evaporator tube section 21 is arranged immediately downstream of the upstream end 24 of the evaporator. The first evaporator section 21 comprises four generally straight tube portions 21a, which are connected, one after the other through three tube bends 21b. The straight tube portions 21a and the tube bends 21b are arranged vertically, one over the other, generally in the same vertical plane. At the downstream end of the lowest straight tube portion 21a, a further tube bend 21c connects the lowest straight tube portion with a further straight tube portion 21d, which extends generally perpendicular to the vertical plane defined by the four straight tube portions 21a, in proximity to the rear wall 2 of the cabinet. At the downstream end of this straight tube portion 21d, the third section 23 of the evaporator is connected to the first section through a tube bend 27. The third section 23 is generally U-shaped and includes two generally straight tube portions 23a connected with each other by a tube bend 23b. The U-shaped third section 23 is arranged generally horizontal, whereby the two straight tube portions 23a and the tube bend 23b are arranged in the same general horizontal plane.

At a lead-through 29, which is arranged through the inner shell of the freezer rear wall portion 2a, at the downstream end of the third evaporator section 23, the third evaporator section 23 is connected to a passive evaporator section 28. The passive section 28 extends inside the rear wall 2 at a slight downward slope, past the partition wall 11 This passive section 28 does not absorb heat from any of the two

compartments. However, it functions as a heat exchanger absorbing heat from the mediums in the conduits 25 and 26. The passive tube section 28 is connected to the upstream end of the second evaporator section 22 at a lead-through 30 in the refrigerator portion 2b of the rear wall 2. The second evaporator section 22 includes two generally straight tube portions 22a, which are arranged, one over the other, generally in the same vertical plane and connected by a tube bend 22b. At the down-stream end of the second evaporator section 22, a lead-through 31 leads the evaporator tube into the rear wall 2, where the evaporator tube, together with the coolant supply conduit 25 is connected to a co-axial gas heat exchanger tube 32. The co-axial tube 32 extends in the rear wall 2, in a generally U-shaped manner and exits through the outer shell of the rear wall. At the back of the refrigerator cabinet, the co-axial tube is connected to the absorber of the refrigerating apparatus (not shown).

During operation, when water is frozen to ice in the ice-maker, the temperature of the refrigeration medium at the upstream end 24 of the first evaporator section 21 is typically maintained at approx. -30 °C. At the downstream end 27 of the first evaporator section 21, the coolant temperature has typically risen to approx. -24 °C. During the passage of the coolant through the third evaporator section 23, the refrigeration medium temperature is raised to approximately -20 °C. During the passage of the coolant through the passive evaporator section 23, the temperature of the refrigeration medium increases due to absorption of heat from the adjacent conduits 25, 26, whereby the temperature at the upstream end of the second evaporator section 22 is about -16 °C. During passage through the second evaporator section 22 the coolant temperature is typically raised to approx. -12 °C. The

different temperatures described above vary over the working cycle of the ice-maker and depending on external conditions as well as customer use. The exemplifying values are given for illustrating a typical operation situation .

For enhancing the heat transfer from the air in the freezer compartment 9 and the refrigerator compartment 10 to the respective evaporator sections 21 and 22, flanged baffle elements 34, 35 of a heat conducting material are attached to the respective evaporator section. The baffle elements 34, 35 exhibit a generally comb-shaped transverse section and include a base and a plurality of flanges having a vertical longitudinal direction.

The flanged baffle element 34 arranged in the freezer compartment 9 is further provided with defrosting means (not shown). These defrosting means comprises an electrical heater. The electrical heater is activated at regular intervals for melting frost, which has been formed on the baffle element. The heater may also be activated when the formation of frost on the baffle element 34 has reached a certain thickness.

As can be seen from the figures, the ice-maker and the baffle element 34 are arranged within the same space, such that air which is exposed to the ice-maker during circulation will pass the baffle element 34. Since this baffle element 34 constitutes the coolest area within the delimited space in which this air may circulate, any humidity absorbed by this air from the ice-maker will form on this baffle element 34. Thereby, all frost caused by the humidity generated by the ice-maker will be defrosted during regular defrosting of the freezer compartment 9.

In the embodiment shown, the baffle element 34, the freezer evaporator 21, the ice-maker and the ice-maker section 23 of

the evaporator are all arranged within the same compartment. This must however not be the case as long as the air is able to circulate between the ice-maker and the freezer evaporator or refrigerator evaporator or the heat conducting element associated with the freezer evaporator or refrigerator evaporator respectively, whichever is provided with means for defrosting frost which is caused by humidity present in the low temperature compartment or the higher temperature compartment.

In one not shown embodiment for instance, the freezer evaporator tube section and the ice-maker evaporator tube section are arranged embedded in the rear wall of the cabinet. The freezer tube section of the evaporator is connected to a baffle element which is arranged in a first space and which comprises defrosting means, while the ice-maker is arranged in the freezer compartment which is formed in a second remotely arranged space. A heat transferring plate or a heat pipe is arranged between the ice-maker and the ice-maker evaporator tube section. Air ducts are further provided between the first and second spaces such that air may circulate between these two spaces. By such an arrangement it is possible to arrange the freezer compartment at distance from the freezer evaporator tube section, which enables a greater flexibility concerning evaporator tube design and the positioning of the low temperature compartment.

By the arrangement of the first, second and third evaporator section 21, 22 and 23 described above, it is accomplished that, during operation of the refrigerating system, the freezer compartment is always cooled by the coolest part of the evaporator, which part also has the lowest evaporation temperature of the refrigerant medium. Hereby, it is assured that the driving temperature difference, between the air in

the freezer and the freezer section of the evaporator, for cooling the freezer compartment always is the greatest possible. This in turn contributes to making it possible to, at all times, maintain the air in the freezer compartment at temperatures as low as −18 °C, which is often desired at modern absorption refrigerators. Further more the arrangement ensures that the humidity load generated by the ice-maker is taken care of by the defrosting means arranged for melting frost generated by humidity present in the air in the low temperature compartment.

The invention further accomplishes that heat added from the ice-maker, during cooling of the water and during heating of the ice for facilitating harvesting, does not significantly affect the evaporation temperature of the refrigeration medium in the freezer section of the evaporator. Studies have shown that the evaporation temperature of the freezer section of the evaporator rises only about 2 °C during operation of the ice-maker at a refrigerator according to the invention. The operation of the ice-maker thereby, does not force the refrigeration apparatus to compensate for heat added from the manufacturing or harvesting of ice. The invention thus provides an absorption refrigerator, at which the temperature of the freezer compartment may be maintained at the desired level regardless of the operation of the ice-maker.

Above, an exemplifying embodiment of the invention has been described. The invention may however be modified within the scope of the appending claims. Instead of being arranged in the lower temperature freezer compartment, the third section of the evaporator may be arranged in the higher temperature refrigerator compartment. In such case the third section is arranged downstream of the passive evaporator section and upstream of the second evaporator section, whereby the third

section of the evaporator or its heat transferring means is provided with means for melting frost formed on said evaporator section or said heat transferring means. The third section of the evaporator may also be arranged in a separate ice-maker compartment which communicates with the low temperature compartment or the higher temperature compartment, depending of which of these compartments communicates with defrosting means.

The first, second and third evaporator sections may have other tube configurations than the ones described above. The may for instance be formed by fewer or more interconnected straight tube portions or they may be formed by tube sections which are curved along their whole lengths.

In the above-illustrated embodiment, the partition wall hermetically seals the freezer and the higher temperature compartments from each other. Small deviations from this principle may be allowed, as long as no significant heat transfer is effected between the two compartments